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Virtual worlds and health: healthcare delivery and simulation opportunities

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Abstract

With decades of experience in simulation, the health professions are comparatively well versed in virtual environments for training. More broadly, there is a growing body of experience and supporting evidence on the benefits of virtual worlds for professional information sharing, clinical simulation, healthcare delivery, and as a research tool. Virtual worlds have empirically demonstrated outcomes as a simulation tool that increases knowledge and of health professionals, and initial explorations in regard to healthcare delivery show promise. Key challenges for wider adoption of virtual worlds within the health professions include a lack of established standards around privacy, a fragmented approach to collaboration and marked skepticism toward virtual worlds as a platform for health care delivery. Recommendations for formalised collaboration mechanisms, agreement on standards, and future research avenues are put forward, with a focus on virtual worlds as a tool that increasingly will be central to professional learning and practice.

Keywords

worlds, virtual, simulation, health, opportunities, healthcare, delivery

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Chapter 17

Virtual Worlds and Health: Healthcare Delivery and Simulation Opportunities

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ABSTRACT

With decades of experience in simulation, the health professions are comparatively well versed in virtual environments for training. More broadly, there is a growing body of experience and supporting evidence on the benefits of virtual worlds for professional information sharing, clinical simulation, healthcare delivery, and as a research tool. Virtual worlds have empirically demonstrated outcomes as a simulation tool that increases knowledge and of health professionals, and initial explorations in regard to healthcare delivery show promise. Key challenges for wider adoption of virtual worlds within the health professions include a lack of established standards around privacy, a fragmented approach to collaboration and marked skepticism toward virtual worlds as a platform for health care delivery. Recommendations for formalised collaboration mechanisms, agreement on standards, and future research avenues are put forward, with a focus on virtual worlds as a tool that increasingly will be central to professional learning and practice.

INTRODUCTION

A majority of the focus on virtual worlds to date has been on their applicability to education more broadly as opposed to health care specifically. For health professionals, health researchers and academics, a range of unique opportunities and challenges present themselves in relation to virtual

worlds, which have evolved to be a cost-effective, clinically appropriate learning tool, health intervention environment and research platform.

This chapter will therefore look at three broad areas on virtual worlds and health. First, the use of virtual worlds for general training purposes and professional information sharing will be discussed. Second, the context for the use of virtual worlds for clinical simulation will be established, including a case study showing its utility in the field of

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surgery. The related area of clinical modeling for more effective health care delivery will also be explored, with examples of work underway on hospital workflow logistics and the use of smart objects. Finally, the use of virtual worlds as a health research tool will be illustrated, with a particular emphasis on the link between virtual world and physical world health behaviours.

The three areas for discussion provide a snapshot of the work underway within the health field, but do not encapsulate its full breadth. The issue of addiction has been purposely avoided as the research base is markedly disparate to the other areas discussed in this chapter, so doing it justice within the space constraints is difficult. For a small proportion of the population, use of virtual worlds can indeed become problematic. This in no way detracts from the larger population that currently and potentially will benefit from virtual worlds, but the negative aspects should not go unacknowledged.

BACKGROUND

Clinical Simulation: The Link to Virtual Worlds

The utilisation of virtual worlds within the health domain has arguably been a longer term one than in other fields. This is predominantly due to the regular use of simulation in the medical, nursing and allied health fields over many decades. The use of three-dimensional (3D) simulations for specific surgical procedures is particularly well established, with the earliest references to its use occurring in 1987 for fibre-endoscopy (Cooper and Taqueti, 2008).

For nursing and most allied health professionals, clinical simulation is also a standard component of undergraduate training and remains a tool for workplace-based learning. The rationales for their use in the health professions are obvious in a lot of respects: a semi-realistic learning envi-

ronment, the ability to make mistakes without causing harm and the ability to reflectively discuss both adverse and desired outcomes. Simulation has traditionally been of a procedural nature i.e. insertion of a urinary catheter, but this has been expanded to the psychosocial aspects of healthcare delivery such as health assessment and counseling, to the point that procedural training may be more considered a clinical laboratory process than true simulation.

There is a large body of research work confirming the efficacy of clinical simulation – with some caveats. A study by Bambini et al (2009) confirmed the utility of traditional simulation mechanisms in improving clinical judgement, communication and general confidence. Gordon and Buckley (2009) in an assessment of graduate nurses' ability to respond to patient clinical emergencies, not only found an improvement in technical confidence but also an increase in non-technical aspects such as information sharing, voicing concerns and using external resources. A systematic review of the 2003–2007 literature on the efficacy of high-fidelity simulation in health sciences training, found an overall increase in assessment and clinical skills performance – whilst also recommending a more rigorous and uniform approach to evaluation of simulation outcomes (Harder, 2010).

A framework proposed by Jeffries (2005) is a useful basis for any discussion on nursing and simulation. The framework identifies the pivotal role simulation can play in generating learning outcomes, whilst increasing satisfaction and self-confidence of those who have participated. It emphasises the role simulation plays in developing critical thinking skills, which are crucial for any nurse to demonstrate competence in an increasingly complex working environment. A discussion paper from Clancy et al (2008) emphasises the utility of virtual environments in simulating complex systems that nurses work within on a daily basis. Specifically, the authors assert that such simulations deliver superior outcomes for

both patient and nurse due to their ability to encapsulate the whole system as opposed to traditional reductionist approaches that attempt to investigate one small aspect in isolation. A 2011 multisite evaluation study of an end-of-life simulation for nursing education demonstrated enhanced student knowledge in caring for someone at the end of their life, as well as increased levels of self confidence, communication skills and satisfaction with the approach overall (Fluharty et al, 2011).

Virtual Worlds and Health: The Broader Picture

The body of research and practice on health and virtual worlds is at formative stages, with an emphasis to date on describing the current and future virtual worlds landscape and recommending broad areas for further research. One key exception to this, as will be discussed below, is psychosocial research in areas such as the link between avatar and physical world health behaviours, viewpoint. The relative familiarity of the health professions with simulation has meant that the step to 3D immersive platforms is a smaller one than for a lot of disciplines. For the sake of this discussion, a virtual world is defined as any platform that provides an immersive, avatar-based three-dimensional space. As will be illustrated in detail below, virtual worlds that offer end-user content creation (such as Second Life, Unity3D and OpenSim) tend to provide the most substantive options for the health professions, but other platforms do provide adjunct benefits for health-based research or interventions, and these will be discussed as well.

The supporting research literature on health-related use of virtual worlds has grown significantly over the past decade in particular. The following table provides a gauge of the explosion in virtual worlds research since 1991. For the sake of this illustration, the use of the search term 'virtual reality and health' was used, with the search completed in January 2011 and limited to peer-

Table 1. Health-related virtual worlds research 1991-2010

Database name	1991-2000 results*	2001-2010 results*
Ovid MEDLINE	48	163
PsycINFO	14	160
CINAHL	199	1729
Google Scholar	56400	115000

reviewed research or authored books (excluding the Google Scholar component).

This growth in research and discussion on virtual worlds and health is most evident in the psychosocial domain, which is unsurprising given the cognitive basis of most current virtual reality experiences. Additionally, the psychology of immersion, addiction and interaction in 3D environments involves complexities that sit intrinsically within the psychosocial domain and tend to be researched from that perspective. The growth in research within the medical and nursing fraternities has remained substantial but of a comparatively smaller quantum. The establishment of journals devoted to the topic area has also fostered the level of research undertaken – The *Journal of Virtual Worlds Research* is one notable example, although *The Journal of Medical Internet Research* and *Presence* also regularly publish peer-reviewed virtual worlds research, amongst others. This is providing the critical mass of publications to ensure less explored aspects of virtual worlds and health are investigated and disseminated.

Some significant challenges remain in regard to the more widespread use of virtual worlds in healthcare training and delivery. First, ensuring a uniform clinical simulation environment for users can be problematic. The higher-end PC requirements for use of a large number of the platforms can provide a roadblock in education environments where numerous learning activities are priorities for the same infrastructure. Second,

there continues to be some instinctive resistance to avatar-based platforms from both those receiving the training and those responsible for delivering it. A qualitative review of six papers on that issue showed that educators unfamiliar with the area tended to assume virtual worlds weren't of real educational value and that they were similar to lower level arcade games (Rice, 2007). Third, for true adoption of these environments for healthcare interventions, significant work around privacy and medical record storage needs to occur. Like their 2D counterparts, virtual worlds have a long way to go before safe and effective medical record storage becomes the status quo.

There are medium-term solutions on the horizon for all of these issues however. The increasing maturity of web-based virtual worlds will assist in driving adoption as the combination of perceived usefulness for communication and ease of use evolves. For the so-called 'digital natives' - those who have grown up knowing nothing other than internet access - there is a natural affinity to using online mechanisms for health information, due to their attitude to technology being informed by their constant exposure (Fetscherin et al, 2008). This exposure is quickly expanding to the use of immersive environments for purposes other than entertainment and socialisation. The success of the American Cancer Society's Relay for Life in Second Life is one such example of non-profit volunteer work being undertaken virtually (ACS, 2008). Overall, there is real momentum toward innovative and cost-effective clinical simulation and virtual worlds are central to this. In relation to privacy and medical records storage, work is well underway to confirm international standards, which could then be implemented within virtual environments.

Augmented Reality: On the Close Horizon

Although Augmented Reality (AR) isn't the focus of this discussion, its combination with

virtual environments for health-related purposes is evolving, with such mechanisms having been touted for more than fifteen years (Kancherla et al, 1995). The ability to overlay information from the virtual environment onto a physical patient or device is the next obvious step in utilisation of virtual worlds in the health professions. One hypothetical example would be the use of avatars for initial training of midwives in antenatal assessment and then using an Augmented Reality mechanism to overlay the key components of the assessment onto a physical patient to bridge the gap between simulation and reality. Inversely, a busy antenatal clinic may collect assessment data from a cohort of women and then use that data to inform the behaviours of the avatars used in clinical simulations. This essentially occurs now in informing the projects developed to date, but AR mechanisms will allow for better synchronisation between learning environments.

An Issue of Promise

Virtual worlds provide both opportunities and challenges in regards to health. The only certainty is that awareness of these environments is critical for all health professionals, in order to gauge their effectiveness for both those within the professions and for the populations they serve. The research base for virtual worlds and health is burgeoning, with much more work yet to be done to establish a concrete foundation for their day-to-day utilisation across the board. To ensure widespread adoption, a rigorous evidence base needs to be confirmed, with the examples cited in this discussion part of the initial cohort achieving that objective.

HEALTH PROFESSIONAL TRAINING AND EDUCATION

Arguably the most obvious use of virtual worlds in the health context comes with the initial or ongoing training of health professionals. Specific clinical

simulation will be covered later in this chapter, however there is a wide range of general health education and training initiatives already implemented within virtual worlds. The availability of more general health science education and training is particularly relevant to disciplines where aspects of health sciences such as biochemistry, genetics and physiology are required as theoretical background rather than being intrinsic to practice. Being able to use immersive options for learning can provide cost effective learning and increase retention of knowledge via increased engagement with the subject matter and a fuller understanding of its context (Cannon-Bowers and Bowers, 2009; Wankel and Kingsley, 2009).

Broadly, the areas where virtual worlds are utilised include health-related science (anatomy, physiology, epidemiology), core health information (diseases, health risk factors) and professional information sharing (forums of mutual clinical interest, conferences). Each will be discussed below, including points on future evolution likely in each area.

Health-Related Science

The use of 3D environments to illustrate health-related science concepts is very well established, particularly within the anatomy and physiology fields. There are numerous non-immersive 3D anatomical modeling options available to students, however those are not the focus here. Using Second Life as an immersive example, over the past five years a range of anatomical models have been developed that provide a particularly unique opportunity: the ability for an avatar to walk through key anatomical structures. A well-established example of this is the Ohio State University's model of the human testis (Danforth, 2008), which has been established in Second Life for well over three years. It provides a large scale, multi-stage anatomical exhibit covering both the structures themselves in addition to detailed, real-

time physiological illustrations - in this case the various stages of sperm development.

Biology concepts are pivotal to most disciplines in the health professions, and a range of work has been conducted in that field in virtual worlds. Evolution, genetics and genetic mutations have been a popular focus from a range of institutions in both Second Life and OpenSim. This popularity is partly due to the scripting language in both environments providing the ability to simulate issues such as mutation in an effective way. One example of this is the work being done in OpenSim by Dr Paul Decelles, whereby evolutionary processes are being explored through replication of virtual organisms (Decelles, 2010). Projects like this provide a useful learning opportunity for health professionals learning the human sciences as it provides an illustrative point that consolidates knowledge in that area.

Epidemiology is another area of interest and from a mainstream media viewpoint, the Massively Multiplayer Online Role-playing Game (MMORPG) World of Warcraft was cited as a test-bed for disease transmission. After a glitch in a 2005 software patch released by Blizzard Software, players who engaged in battle with a dungeon boss called 'Hakkar', were infected with 'Corrupted Blood' which depleted their health. This is a normal gameplay mechanic, but in this specific case the disease was able to be transferred out of the dungeon in question to the wider World of Warcraft population. This led to widespread 'deaths' amongst lower-level players, with the associated inconvenience of needing to walk back to one's corpse in-game. A discussion paper by Logfren and Fefferman (2007) citing this particular event, identified the opportunities for reproducing epidemic scenarios using large virtual environments like World of Warcraft.

There were key weaknesses in the 2005 event however, including the fact that the transmissibility was 100% and the level of applicability to physical world human movements was limited - there has been a degree of criticism of the level

Figure 1. Dalaran – a city in *World of Warcraft*



of enthusiasm about what is argued as a flawed model (Williams, 2010). That said, the use of virtual worlds for epidemiological research remains a fertile area for exploration. In a discussion paper on modeling epidemics, Gordon et al (2009b) make the argument that the link between avatar and human is potentially strong enough in freer environments like Second Life to allow for substantive modeling of epidemics such as HIV/AIDS transmission due to the ability for all the relevant behaviours to be simulated. Although outcomes to date have been sparse in this specific area, there is certainly agreement that virtual worlds can be a useful adjunct to physical world modeling. With the ongoing growth of virtual worlds usage and as these worlds become more nuanced, the potential for epidemiological research grows even more evident.

Consumer Health Information Provision and Support

As a collaborative, social platform, virtual worlds provide a strong option as a health information

and health support tool. This is an area where less complex worlds such as IMVU and Habbo also boast communities with a health-specific focus, but this discussion will focus on the more complex communities and presences that have evolved.

The University of Plymouth has a presence in Second Life dating back to July 2007, devoted to sexual health education. It combines video tutorials, live seminars and interactive quizzes and initial evaluations has shown it to be popular although determining outcomes is problematic, given the limitations in measuring traffic to particular areas in Second Life. One of the cited successes came with a seminar on sex and disability, with the presenting speaker stating that the attendance was much higher in Second Life than it would have been face-to-face due to the sensitivity of the topic (Kamel Boulos and Toth-Cohen, 2009; Kamel Boulos, 2010). In the absence of metrics gleaned from the virtual world platform, more traditional session evaluation tools continue to be pivotal, and even as in-world measurement improves, those tools will continue to be important.

During 2010 a research project was undertaken by Murdoch University's Kirsty Best, on the utility of Second Life for supporting those experiencing Myalgic Encephalitis/Chronic Fatigue Syndrome. The qualitative research focused on the role of Second Life as a means to reduce social isolation for those experiencing the illness. At time of writing the feedback from participants was showing outcomes in regard to lessened social isolation and increased knowledge around managing life with Myalgic Encephalitis / Chronic Fatigue Syndrome. Cited negatives included the complexity of the technology and issues for some participants in installing and using Second Life effectively (Holloway, 2010).

A project led by the Texas Obesity Research Center at the University of Houston is also worth noting in this section because of its focus on providing evidence-based information around obesity. For the research, active recruitment was undertaken within Second Life, with 162 participants taking part in a range of interventions including extensive information provision on diet and physical activity. Activities were centred on three areas: a 'Café Pavilion', 'Physical Activity Pavilion' and 'Information Pavilion'. Specific activities included choosing foodstuffs from a virtual refrigerator with associated recipes and dietary guidelines, avatar engagement in physical activities such as walking and jumping for 30 minutes maximum per day, and completion of questionnaires on diet and physical activity. The results of the project showed mixed results - on the positive side, the authors state that "obesity prevention interventions can be effectively designed and implemented within virtual worlds" (Siddiqi et al 2010). Less desirable outcomes revolved around retention of participants and user-experience issues with Second Life – a regular finding of virtual worlds research to date.

The three examples cited here illustrate the ability for health professionals to disseminate relevant information to populations that may be otherwise difficult to access, or where the sensitivity of

the topic makes face-to-face interventions more challenging. Additionally, health professionals can learn a great deal from the communities of mutual interest that have developed around health issues – such groups provide an ideal base on which to build collaborative projects with health consumers.

Professional Information Sharing

The use of virtual worlds for information sharing between health professionals is well-established. Second Life has been the focus of the majority of work, although more recently OpenSim has gained significant traction, as has Unity3D. One of the key challenges in this area is actually defining the scale of information sharing occurring.

This author has encountered a range of professional groups within Second Life since 2006, including nursing, medicine, counseling and mental health. Some come under the auspice of professional bodies; others are driven by university academics, with the remainder being formed by communities of interest within professions. One of the latter is the Online Therapy Institute, which focuses on Second Life and its usefulness in counseling / therapy. Founders DeeAnna Merz Nagel and Kate Anthony see virtual worlds offering an improved level of sensory experience over other 'remote' counseling modalities such as web-chat and discussion forums, with a related improvement in therapeutic outcomes (Holloway, 2009). Their initial work in Second Life has been in the information-sharing domain, providing familiarity instruction and a virtual space for collegiate interaction. There is an acceptance that virtual worlds like Second Life do continue to have limitations in regard to establishing identity and ensuring privacy (Gorini et al, 2008), and that until such issues are resolved it is difficult to offer substantive counselling interventions outside of finite research study boundaries. The concepts of privacy and identity in virtual worlds are fraught with challenges, including the likelihood that an

individual seeking counselling within a virtual world is predicated on a desire for absolute anonymity, and the professional challenges that brings.

Another noteworthy example of professional information sharing is the International Virtual Association of Surgeons (IVAS), which had its first conference in 2008. Initiated as a demonstration of the cost-effectiveness of virtual conferences, the central purpose of the meetings are sharing of information, including discussion of medical imaging, research studies and related professional issues. IVAS' continued growth is not assured however, with concerns acknowledged around verifying identity and the inability to conduct true hands-on workshops that would be possible in a face-to-face context (Leong et al, 2008). However, the fact that IVAS has had some success to date within one of the most highly-technical, 'hands-on' professions, bodes well for the use of virtual worlds more widely as an information sharing tool.

Looking at the issue of information sharing in virtual worlds more broadly, the use of open-source virtual worlds like OpenSim will arguably lead to more effective information sharing, for three reasons. First, there is an established body of evidence that the success of virtual communities is related to the degree of system quality, service quality and information quality (Lin and Lee, 2006). Therefore, OpenSim's lower price point, ability for greater end-user customisation and the boutique customer service approach by some grid administrators meet those criteria for success. Second, the ability to create an OpenSim-based world behind a firewall at minimal cost provides a superior option for professional information sharing where security of information is a priority or where the scale of content creation makes worlds like Second Life cost-prohibitive. Finally, collaboration in the health professions is most successful where common structures are in place, and OpenSim provides interoperability with Second Life and the gamut of OpenSim-related grids.

In the longer term, the drive toward secure, interoperable virtual environments that provide

nuanced content creation options will be critical for the adoption of virtual worlds as a central information-sharing tool for the health professions. At present, those involved are early-adopters and innovators providing proof-of-concept modeling that will form the basis of that longer-term view.

CLINICAL SIMULATION

Virtual Worlds as Simulation

As discussed in the Background section above, clinical simulation is a well entrenched learning tool with a significant body of evidence supporting it. The large majority of this evidence revolves around the use of simulation laboratory settings rather than virtual environments; however, the body of literature on simulation and virtual worlds is growing as well. It is also arguable that the bulk of the evidence supporting laboratory simulation can be applied to virtual worlds to some extent, in that virtual worlds are essentially another tool in the simulation arsenal. There are certainly issues specific to these environments that do not apply to more traditional simulations, but there are as many similarities as differences. Cooper and Taqueti (2004) illustrate the lack of clarity around the clinical simulation field generally, citing the fact that in procedural simulation, there has been no review of the field and that there remains confusion over definitions and outcomes of simulation beyond a particular device or approach. A review of surgical simulation by Sturm et al (2008) found that although clinical simulation did transfer successfully to the live clinical environment, the ten randomized trials and one comparative study were "of variable quality and did not use comparable simulation-based training methodologies".

The lack of definitional clarity to date with clinical simulation provides a unique opportunity for the nascent area of virtual worlds-based simulation. Because of the relative infancy of 3D virtual worlds, the reality is that there are only a

handful of platforms complex enough to accommodate effective simulation. If work is continued on standardisation and interoperability between platforms, then some of the pitfalls of the simulation field more widely (lack of replication of research areas, fragmentation of approaches) may be avoided. There has been some significant work on this to date, through the open-source OpenSim and its high degree of interoperability with Second Life protocols. Additionally, OpenSim allows for use of other virtual worlds protocols, which has been demonstrated successfully with the Unity3d platform over the past couple of years (Hughes, 2009). If the level of cooperative evolution and innovation continues, then more rigorous research outcomes are likely to be generated as the foundation on which research methodologies are applied becomes more solid and widely accepted.

Clinical Simulation: Limitations and Successes

In addition to the Imperial College case study given below, a number of virtual world clinical simulations have been developed that have demonstrated positive outcomes. All have a commonality in that they address specific clinical pathways, require accurate replication of clinical decision-making and provide a comprehensive simulation experience transferable to actual clinical practice. Additionally, each has cited similar limitations that require further investigation. To illustrate the specifics of the successful and not-so-successful aspects of clinical simulation, it is pertinent to cite two examples: the Second Life in Education in New Zealand (SLENZ) project and a research initiative by the University of Alberta.

The SLENZ project contained a midwifery clinical simulation at the core of its activities, with the aim to build (in Second Life) a best-practice birthing unit, within which midwifery students could then be trained in a range of aspects of the birthing process from the initial phone call from the expectant mother through to delivery of post-

natal care. According to a qualitative evaluation undertaken on the project (Winter, 2010), the combination of the best-practice birthing facility and the ability for students to role-play both the midwife and birthing woman provided useful outcomes from the perspective of both the students and the educators. More specifically, a number of the students participating had their skepticism toward the virtual world simulation (and to some extent Second Life) turned around to the point of agreement that the simulation was a very useful tool. On the negative side, both the students and the educators involved found the learning curve for Second Life quite steep, experienced technical difficulties including bandwidth issues due to the remote locations of some students, and found that the need to employ an experienced Second Life content creator provided a set of challenges (Winter, 2010).

The University of Alberta initiative also contained two aspects. The first was the development of scenario-based training simulations for Emergency Medical Technicians (EMT) that involved procedural and communication domains. The second was a communications skills education program utilising 'Standardized Patients' – in this case Second Life avatars. In both cases, similar outcomes to the SLENZ experience were demonstrated, with yet again an emphasis on the inherent limitations of consumer virtual worlds like Second Life and a desire for exploration of even more flexible and comprehensive environments for simulation development (Chodos et al, 2010).

The SLENZ and University of Alberta experiences to a large extent encapsulate the challenges for simulation in non-specialist virtual environments. There is a growing awareness of their usefulness, mixed with concerns over their complexity and the need to overcome resistance to their use. This resistance is exacerbated by negative coverage by some of the mainstream media revolving around sex, gambling, addiction and relationship breakdowns. Once relevant exposure to virtual worlds occurs, resistance tends

to break down and in its place awareness develops of the scope of learning opportunities that these environments provide.

Simulation: The Future

Although simulation is one of the most well entrenched aspects of virtual environments and health, the drive to improve the quality of simulation is greater than ever. The cost-effectiveness of virtual worlds like OpenSim and Second Life, whilst providing opportunities for more widespread simulation use, have a great deal of evolution to undertake before providing the level of immersion that some of the more specialist virtual reality devices can provide. That evolution is likely to occur at an increasingly accelerated pace, is likely to have mirroring of physical world data at its core, and will heavily involve augmented reality mechanisms where appropriate. The increasing interest by government in the use of virtual worlds may also provide a catalyst for more substantive funding of non-commercial virtual worlds development. The United States Government in particular has an active virtual worlds strategy and the conjunction of the Defense Forces' interest in virtual worlds support for returned servicemen (as discussed below) is likely to be one of the key drivers for quality improvement in the space worldwide.

Case Study: Imperial College London

Surgical simulation is well entrenched in medical training, but widening its use has been dependent on cost and availability. The Department of Biosurgery and Surgical Technology at the Imperial College London, formed the Medical Media and Design Laboratory (MMDL) in 2007, focused specifically on "innovative and efficient means for communicating complex health messages, the visualisation of future health care delivery models, medical device development, professional networking and educational tools for patients and

staff." (Imperial College London, 2010). Over the time of its operation, the MMDL has instigated a number of projects:

Medical Device Education

A simulation was created within Second Life designed to increase familiarity with specific medical devices such as insulin infusion pumps. Eleven surgical nurses, of which ten were novice users of the specific insulin pump, completed a clinical scenario with a scripted patient avatar and an in-world instructor. The feedback from the nurses involved showed that all felt it was a useful training tool, there was increased confidence in using the physical world equivalent of the device, and 82% were willing to recommend the training to colleagues (Kinross et al, 2009). The applicability of medical device familiarity training for both emerging and experienced clinicians is absolute: just as virtual worlds continue to evolve at a rapid pace, so do the iterations of medical devices available. For universities and health delivery services, the ability to script virtual world objects that replicate new medical devices is both cost-effective and clinically effective in that most educators are unable to supply real working versions of each new medical device being used.

Clinical Scenarios

A number of clinical scenarios have been developed for both doctors and nurses, to develop clinical decision-making skills. In this instance, an avatar patient was scripted to exhibit a range of symptoms, with the health professional required to undertake an appropriate assessment, make a relevant diagnosis and provide the appropriate care with the equipment provided in the simulation (Imperial College London, 2010). The degree of intricacy of the simulation allows for a near-direct mirroring of actual clinical practice and work environment, which informed the development of the hospital wards and treatment areas. At time of writing, substantive outcomes of the clinical scenarios were still being written

up, with the MMDL team confident of replicating the medical device study results cited above in regard to learning outcomes. Another related project underway involves a scenario designed to train health professionals in gaining informed consent from individuals with a learning disability. The 'Pathways for Consent' project, although quite different to assessing medical needs, uses the same delivery medium and is essentially identical in that the highly configurable nature of objects in Second Life means that a unique simulation experience is generated.

CLINICAL WORKFLOW MODELING

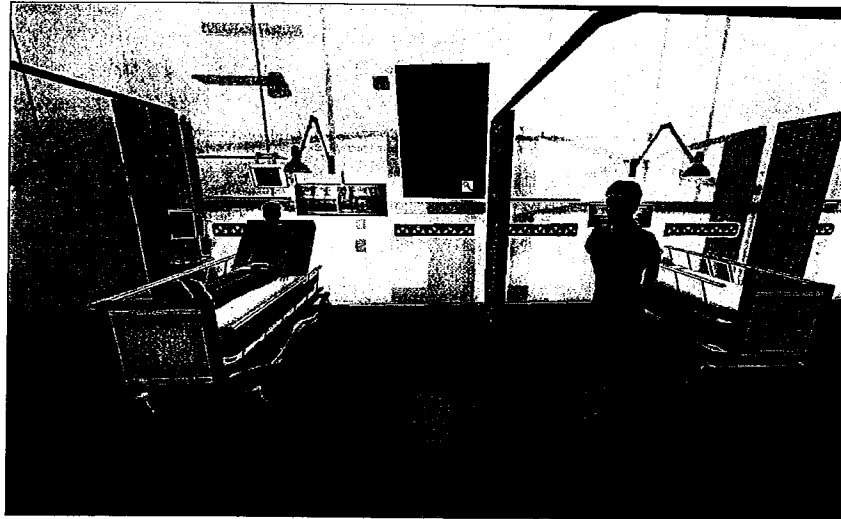
Unlike clinical simulation, which tends to be focused on individual outcomes, clinical modeling primarily involves processes and workflow. The ability to create content in virtual worlds that replicates the physical world provides a number of opportunities for those looking at improving how medical facilities work, whether they be hospitals, ambulances or community health centres. Thompson and Hagstrom (2008) provide a useful summary of the link between smart objects, health care and virtual worlds. The key benefit is the ability to test the interaction of smart objects such as Radio Frequency Identification (RFID) tagged devices with the wider facility environment to determine both the benefits and challenges of that interaction. Using a hospital as an example, smart objects may be the medical devices that adjust their behaviour based on biometric data, the lighting system that ranges from low light to operating theatre quality depending on the number of staff present in the room, or an orthopaedic chair that communicates with each patient's RFID tag and adjusts its position based on clinical need. The modeling of these devices within the virtual world allows for the identification of issues and prioritisation of improvements. As Eguchi and Thompson (2010) state: "the smart object interface protocols we develop can be platform-agnostic, so they can

operate either in the real or virtual world". This is the critical point for clinical modeling in virtual worlds: direct interoperability with the physical one. Once that has been achieved, a major barrier to widespread acceptance amongst the health professions is potentially overcome – the concern over applicability to everyday practice.

Stroulia et al (2009) illustrate the close interaction between the virtual and physical worlds with their Smart Condo project. It provides for assisted living at home through the extensive use of sensors to support a range of medical and daily living needs, with the data gathered visualised within Second Life. Once again there is an opportunity to use physical world trends, in this case home-based care as a cost-effective alternative to traditional care options, to promote the effectiveness of virtual worlds in healthcare delivery – in this case to visualise clinical data. To state the case even more emphatically: there is finally the potential to build a useful clinical picture of an individual's management of their health and related activities of daily living, in their own home, with its implications for improved management including the crucial psychosocial aspects of health.

Although the work on clinical modeling in virtual worlds is at a formative stage, it does provide an opportunity to increase awareness of its usefulness amongst populations of people who may not otherwise have realised its application. The work on smart objects and assisted living gives virtual worlds a direct influence on activities of daily living for elderly people, or others with multiple co-morbidities including chronic disease. This not only involves their use as test-beds for physical world implementation, but includes their use as data visualisation tools for health professionals involved in case coordination of numerous individuals with varied health issues. The data visualization aspect also potentially provides the opportunity for a health professional to replicate a complex in-home model for a different individual with similar needs, saving time and money com-

Figure 2. An avatar patient for assessment



pared to starting over for each person. Once this level of adoption has occurred, virtual worlds will be no stranger a concept than personal medical alarms are currently.

VIRTUAL WORLDS RESEARCH AND HEALTH OUTCOMES

Intrinsic to the progression of any field is the ability to bridge the divide between research and practice. The driving force for the health professions is improving the health of individuals and the communities they reside in, so given the relatively short existence of 3D virtual worlds, the real health outcomes being demonstrated are encouraging. Two broad categories encapsulate the work completed to date: studies comparing virtual worlds to other modalities, and virtual worlds specific research, with the latter the focus of this discussion. The unique attributes of the virtual world environment provides both opportunities and challenges for the researcher, particularly around issues of consent, confirming identity and scheduling follow-up where required. The focus of a lot of research undertaken within virtual worlds

has fallen into two areas: ethnographic studies of behaviour, or measurement of impact on actual health (mental or physical).

Ethnographic Studies

Virtual worlds by their nature offer a different level of interaction between individuals and groups compared to either physical world interactions or non-3D online interactions. Ethnographic studies of virtual worlds populations have occurred for well over a decade, a notable example being the detailed study of a multi-user dimension (MUD) written by Cherny (1999). A striking recent example is a study by Portnoy et al (2010), which investigated the degree to which virtual environments could indicate propensity to engage in risky interpersonal behaviours, even though the ramifications of virtually exhibiting those behaviours is essentially non-existent. As has been demonstrated in a range of contexts across virtual worlds research, the results showed that the sense of presence generated for the participants was significant enough to perceive interpersonal risk in the absence of actual negative consequences.

Sexuality and sexual health have been one of the more dominant aspects of ethnographic research undertaken to date, and this is an area that has obvious connotations for the health sector. Boellstorf (2008), in his extensive anthropological investigation of *Second Life*, devotes a significant amount of time to the issues of intimacy, friendship and sexuality. Not surprisingly there were a range of views expressed to the author during his fieldwork, but the common and somewhat unsurprising theme is that to a large degree, the behaviours exhibited in virtual worlds either are a reflection of, or a reaction to, their physical world iterations. To a large extent this is the central value of health research in virtual worlds: the ability to engage with people who are using virtual worlds to express themselves more openly than they otherwise would have. This can lead to the identification of strategies to improve health outcomes, delivered within virtual worlds, in more traditional health contexts, or in both environments. The real power of ethnographic research for the health professions is reinforcing the fact that virtual worlds are not a technological aspect to be factored in – they are just another extension of human expression that needs to be considered in a holistic approach to health.

Health Impacts

One of the larger bodies of evidence that demonstrates the impact of virtuality on health, is research into the use of virtual reality to ameliorate the effects of Post Traumatic Stress Disorder (PTSD). One of the more recent studies by Wood et al (2010) involved the use of virtual reality tools in treating 30 military personnel over 350 sessions, with the results confirming the use of Virtual Reality Exposure Therapy as an effective and safe intervention. Rizzo et al (2009) investigated the use of the 'Virtual Iraq / Afghanistan' PTSD Therapy Application on 20 personnel and found that 16 no longer met the diagnostic criteria for PTSD after treatment. During 2010, the United States' Defense

Advanced Research Projects Agency (DARPA) announced a funding opportunity to develop its 'Healing Heroes' program, which is to provide comprehensive telehealth support to its active and veteran military personnel who have experienced PTSD, traumatic brain injury or major depressive episodes. The first layer of the support requested for development is "avatar-based simulation, virtual environments, serious games, web comics, and other forms of 'new media'" (DARPA, 2010).

The research to date on PTSD and virtual environments illustrates to a large extent the roadmap for virtual worlds development in coming years. The military-level work in this area involves more than just visual and auditory immersion – the use of smells, sensations and temperature are also utilised, as are a range of mechanisms such as meditation, visualisation techniques and physiological monitoring. Translated to the broader community, these more intensive immersive techniques are already being utilized. Gaming consoles like the Nintendo Wii have provided a lot of momentum in regard to promulgating the concept of haptic interfaces, with research supporting the use of virtual reality as an adjunct to other treatments. With the technology now at a consumer level, it is allowing more widespread analysis of its efficacy. Using virtual reality for individuals who have had a stroke has led to more effective rehabilitation (Merians et al, 2002; Kim et al 2008). A subsequent study using the Nintendo Wii has also demonstrated positive rehabilitation outcomes (Saposnik et al, 2010). Other platforms such as the Sony Playstation and Microsoft Xbox have recently followed suit with location aware controllers or motion detection, further cementing the approach in the wider community.

A final area of significant momentum in virtual worlds health research, is on the link between an individual's physical world health behaviours and those of the avatar they control. The link between the size, shape and physical activity behaviours is a focus of interest for its potential application to preventative health measures in a society where

gaming and sedentary pursuits have continued to grow. A study by Dean et al (2009) utilized 'heavy' and 'thin' avatars in Second Life to interview respondents on their physical activity and weight. The published findings involve only 29 respondents and the authors emphasise the findings as preliminary, but they warrant discussion for the trends they flag. The first outcome was support for the hypothesis that those engaging in physical activities in Second Life were more likely to engage in physical world exercise. Second, those who had thin avatars reported a lower average Body Mass Index than those with larger avatar sizes. Finally, those who were interviewed by a researcher with a thin avatar were nearly twice as likely (64.3% versus 33.3%) to report that they believed their avatar to be also thin. The respondents interviewed by the heavy avatar were nearly twice as likely to report that they didn't believe their physical world weight and size to be 'about right' compared to those interviewed by the thin avatar (66.7% versus 35.7%). These findings, when expanded upon with further research, are likely to be pivotal in regard to the design of health interventions within virtual environments.

SOLUTIONS AND RECOMMENDATIONS

The claim is repeatedly made in this chapter that virtual worlds provide a useful option for the health professions, albeit at an early stage of development. For the adoption of these environments to become widespread and intrinsic to both education and clinical practice, it is proposed that the following steps need to occur:

Interoperability

The current state of play with interoperability between virtual worlds is mixed. Although OpenSim and Second Life have commonalities, and the hypergrid protocol allows for movement between

OpenSim worlds, there remains a raft of difficulties. A more formalised dialogue needs to be established, with the aim of maximising interoperability between all virtual environments. There is some significant momentum toward web-based virtual worlds and this may be the foundation of interoperability efforts, but the ideal outcome would be an outcome-driven interoperability framework rather than one driven by technology considerations only. Any such developments should include input by educators and health professionals.

Agreement on Standards for Simulation in Virtual Worlds

The research literature on the use of simulation in the health professions points to the need for agreement on simulation standards to ensure maximum quality of simulation but also to provide the basis on which more significant, replicable research can be undertaken. Development of standards would require an inter-disciplinary body, which would seek input from each profession on needs idiosyncratic to that profession. The scale of such an undertaking would best be integrated into current professional peak body structures – although the current level of awareness of virtual worlds issues makes this a longer-term proposition. In the meantime, key innovators in the field collaborating on standardisation would provide the impetus for the work required.

Central Directory of Places for Professional Information Sharing

The current body of health information existing within virtual worlds is highly fragmented, and due to the well-developed virtual worlds being 3D, data is difficult to search for in the traditional sense. The vacuum has been filled to date by informal efforts around Wikis and other knowledge-bases. There remains a need for a peer-refereed repository of information on virtual worlds and health. The ability to achieve this will hinge on the broader

issue of acceptance of virtual worlds as a key tool for the health professions, as only then will there be a 'specialty' that resources can be devoted to.

E-Health Standards Compliance

Critical to the evolution of virtual worlds as a health intervention will be their articulation with emerging e-health standards. The Health Level Seven (HL7) protocols have been under development for many years, and user interfaces are a core component (Health Level Seven International, 2010). Ensuring that future virtual worlds development is cognisant of HL7 standards is the key part of the equation – the standards themselves are broad enough to easily accommodate the needs of new virtual worlds applications.

Further Development of Expertise in Data Visualisation Within the Health Professions

With few exceptions, a disconnect exists between those developing virtual worlds and interpreting their data, and the health professions. With the burgeoning growth in online health initiatives, there needs to be a greater emphasis on capability development in data visualisation within the health field. This has obviously already occurred with the growth in health informatics as a specialty, but the sub-specialty of analysing the data gleaned from virtual worlds interventions and its relationship to real world outcomes, is at best in its infancy.

An Agreed Research Agenda for the Health Professions

As has been demonstrated in this discussion, there remains an enormous amount of work to be done to establish the empirical framework for the use of virtual worlds in health. Like any research endeavour, it needs to be driven by the key decision-makers within each respective field. In most cases these are the educators and senior

clinicians who determine both research and education priorities. Without a collaborative dialogue, the risk of unwanted replication of research in some areas, lack of replication in others and no research activity in key areas remains a high risk. The growing interest in translational research provides some promise here, as the professions look to take advantage of the linking opportunities such an approach engenders.

FUTURE RESEARCH DIRECTIONS

The scope for future research in regard to virtual worlds and health is enormous. The nature of virtual worlds has provided some challenges for researchers attempting to apply traditional research techniques, but adaptation has certainly occurred and will continue to evolve. A key component of future research will be the establishment of agreed approaches to data collection in virtual worlds where establishing identity can be challenging and where protecting privacy rightly remains a key concern.

More specifically, it is proposed that the following research areas warrant particular attention:

Avatars as Vehicles for Health Behaviour Change

The research to date on the link between avatars and physical world lifestyle change is promising. Further in-depth quantitative studies looking at the outcomes of virtual world health interventions around lifestyle risk factors need to be undertaken. This may revolve around an interactive module offered within a virtual environment, with group support also provided in the same context. To ensure that any evidence of success is emphatic, the measurement of outcomes should include objective biometric measurements rather than reliance on self-reported data as has largely occurred to date.

Therapeutic Interventions for Distorted Body Image

As discussed above, perception of self appears to translate to an individual's avatar, and vice-versa. Further research on the psychology and sociology of body image and therapeutic interventions delivered in virtual worlds could provide another tool to engage individuals who otherwise may not seek out assistance. The efficacy of computer-brain interfaces to directly control avatar appearance with thoughts or emotions is a related area deserving of further attention.

Decision-Making

Research on simulation supporting clinical decision-making is well established, but decision-making more broadly needs further exploration. Whether it is sexuality, substance use, peer interaction or informed consent, virtual worlds provide a unique option that needs rigorous definition. Creating scenarios in virtual environments that inculcate decision-making skills is a relatively simple task that could deliver substantial outcomes in a range of health-related areas, particularly in enhancing confidence and competence in clinical practice.

Integration

The acceptance of virtual worlds within the health professions will require a solid evidence base that places them within an overall framework rather than as a standalone tool. This is already the case to some extent, but further research that demonstrates the successful integration of face-to-face, 2D online and 3D online aspects is required, whether as a health intervention or clinical education tool.

CONCLUSION

Health professionals have never faced bigger challenges in managing the health of individuals

or populations. The pace of technological change, combined with the shrinking health workforce comparative to a growing population, means that cost-effective options for training, collaboration and intervention has never been more imperative. There is a respected history within the health professions for clinical simulation, and this is likely to provide the basis on which acceptance of virtual worlds will become widespread within the university sector. Like any initiatives adopted academically, the ability to bridge the gap between theory and clinical practice will be critical in the coming decade to ensure this emerging field gains the attention it deserves. There is no certainty that virtual worlds will become central to clinical practice. What is certain is that virtual worlds hold enough promise to test their claims in a detailed and rigorous way, to support the research to date that points to their ability to gain health outcomes not able to be achieved elsewhere. It is the uniqueness of virtual environments, combined with the emotional power that individuals place in their avatars, that makes a powerful case for collaborative translational research to confirm the role virtual worlds will play in the health professions.

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KEY TERMS AND DEFINITIONS

OpenSim: an open-source virtual world platform loosely based on the Second Life architecture.

Second Life: a virtual world in existence since 2002 which allows creation of unique content that remains the intellectual property of the creator.

Simulation: the utilisation of methods to replicate real clinical situations without causing harm.

Unity3D: A multi-platform game development tool with relatively simple content creations options and the ability to create web-based virtual worlds.

Virtual World: a computer-based simulated environment, within which users can interact and create objects.